To: ECGVM Workshop
From: Dan MacMillan
Subject: Precision of the Best VLBI Experiment Series

1) How good is baseline length repeatability (wrms) for the best experiment series (R1, R4, CONT02, RDV)?

R1/R4: $\text{wrms} = \sqrt{(2.5\text{ mm})^2 + (1.67\text{ ppb})^2 * L^2}$
(This would be better if the TIGOCONC baselines were removed)

CONT02: $\text{wrms} = \sqrt{(1.2\text{ mm})^2 + (0.90\text{ ppb})^2 * L^2}$

RDV: $\text{wrms} = \sqrt{(1.5\text{ mm})^2 + (0.96\text{ ppb})^2 * L^2}$

2) Do better stations produce better baseline wrms?

As a test, consider the 10 VLBA antennas, which are essentially identical in design and generally better than the geodetic antennas.

Three RDV solutions were done:

a) Use data from both VLBA and non-VLBA antennas
b) Use only data from VLBA antennas
c) Use only data from non-VLBA antennas

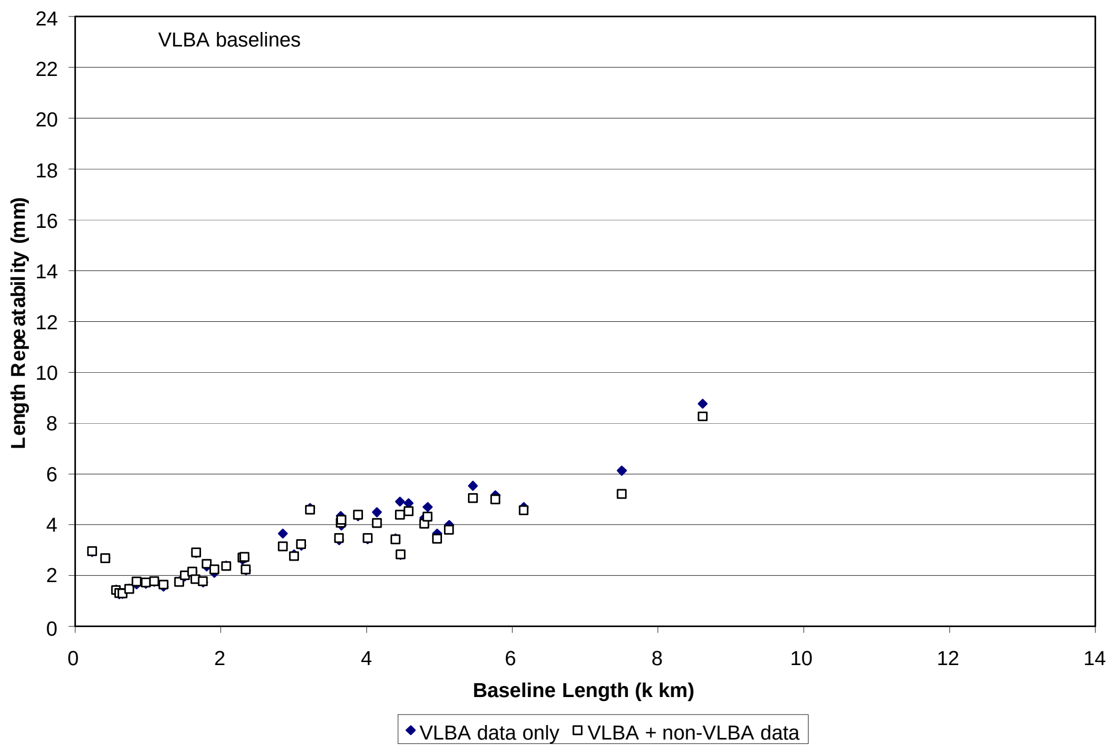
Analysis of the RDV sessions (10 VLBA antennas + (8-10) geodetic antennas) =>

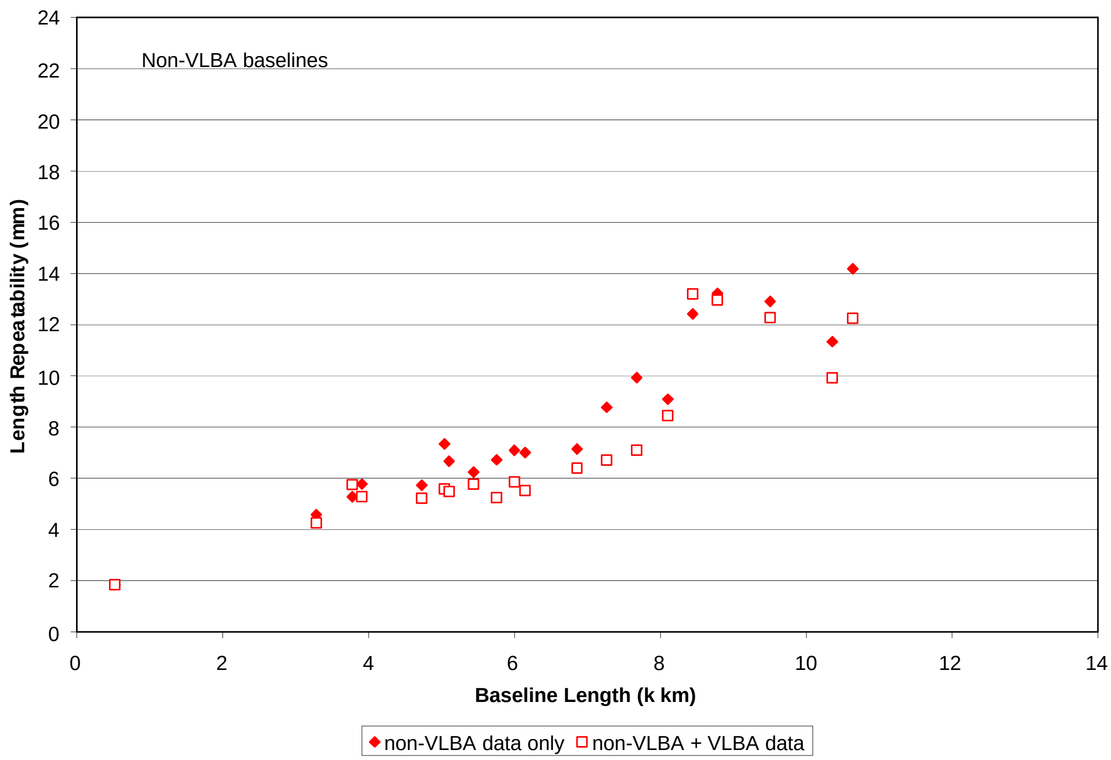
The inclusion of data from VLBA antennas improves non-VLBA baseline wrms; non-VLBA antennas only improve VLBA baseline length wrms minimally at the longest baseline lengths.

VLBA baseline length wrms are better than for non-VLBA but not dramatically better. One problem with the comparison is that there are few VLBA baselines longer than ~6000 km.

VLBA station data only: $\text{wrms} = \sqrt{(1.7\text{ mm})^2 + (0.86\text{ ppb})^2 * L^2}$

Non-VLBA station data only: $\text{wrms} = \sqrt{(2.0\text{ mm})^2 + (1.18\text{ ppb})^2 * L^2}$


VLBA baselines
Length Repeatability (mm)
Baseline Length (k km)
VLBA data only
VLBA + non-VLBA data


Non-VLBA baselines
Length Repeatability (mm)
Baseline Length (k km)
non-VLBA data only
non-VLBA + VLBA data

3) How much of the observed error (wrms) is due to unmodeled error?

Background: The chi2/dof = 2-3 for linear fits (offset + rate) to observed baseline length time series. We have interpreted this as meaning that the formal errors were underestimated by a factor of ~ 1.5 => unmodeled error ~ modeled error

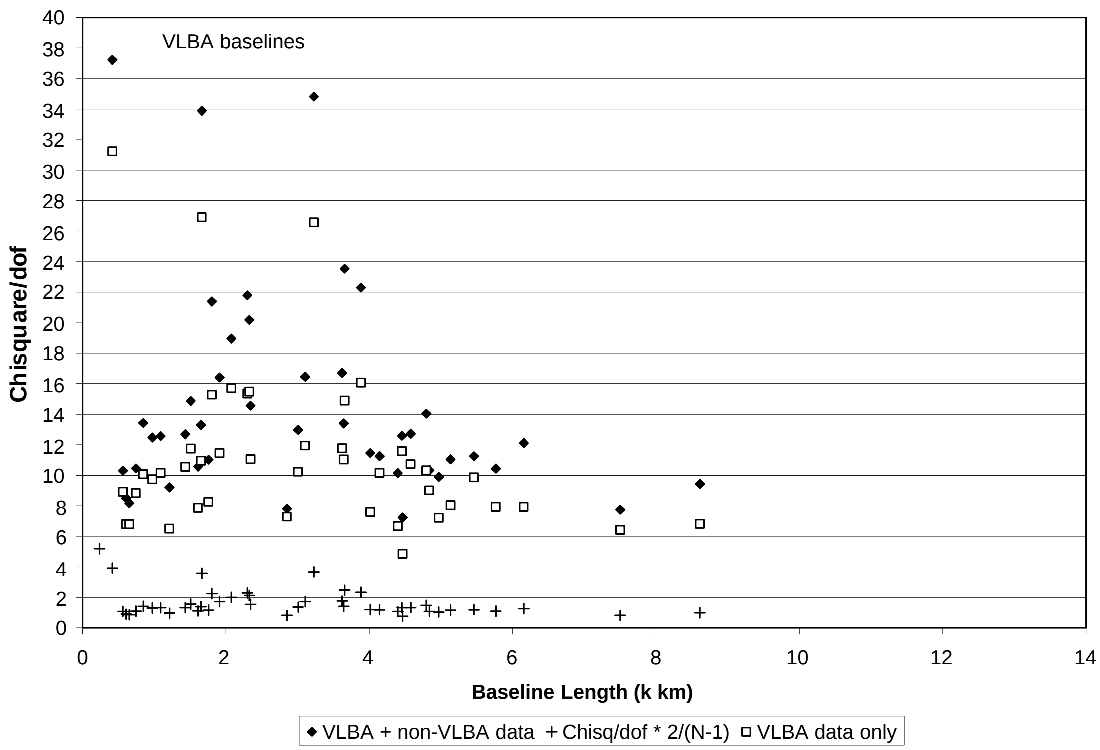
Chi2/dof = 1-6 for R1/R4 series (6-8 station networks)

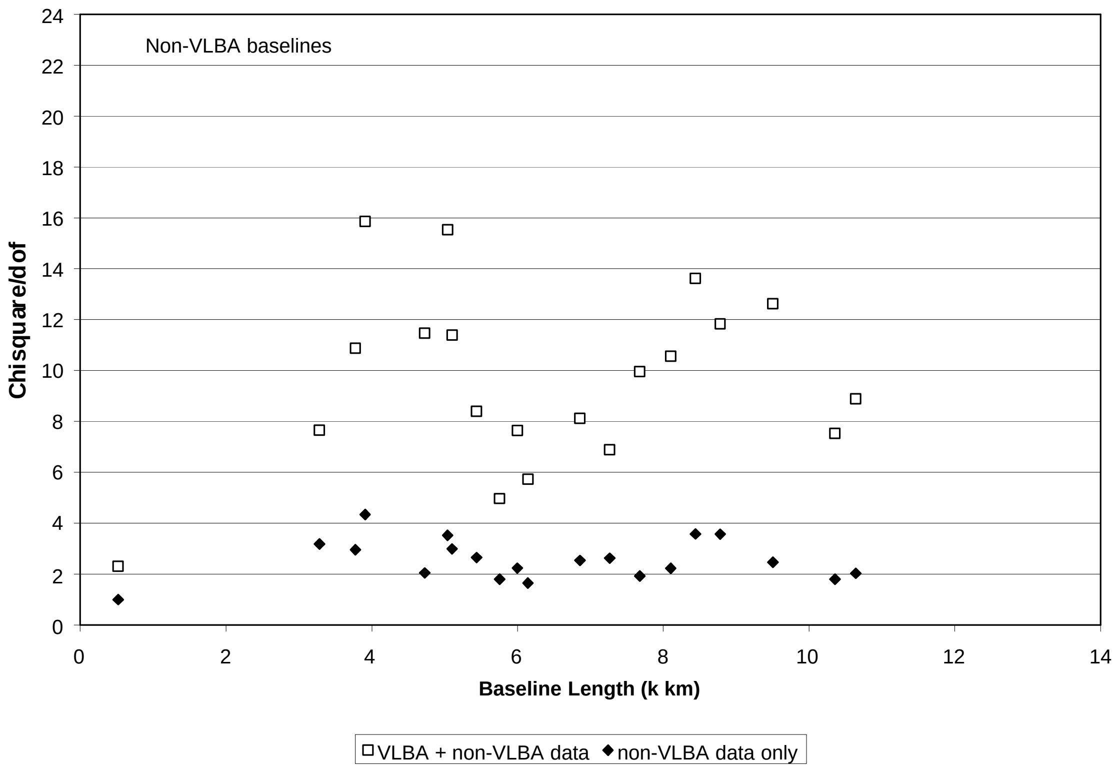
= 5-20 for RDV series (18-20 station networks)

=> Formal uncertainties must be underestimated and this effect increases with network size.

=> For a network of N stations, we will have N(N-1)/2 baselines and that many observations for a full network scan. These observations are not independent and we have not accounted for the correlations between observations on baselines sharing the same station during a scan.

Below are shown the Chisquares/dof for the different RDV solutions described in 2)





4) Troposphere delay modeling error

Elevation cutoff tests were made to look at the dependence of baseline length wrms on the minimum elevation angle of observations and the effect of using an improved hydrostatic mapping function, IMF (derived from numerical weather model profiles at 6 hour intervals) rather than NMF. [A. Niell derived both of these.] For the cutoff test, observation below a given elevation angle are removed from the solution.

As elevation angle decreases, tropospheric delay errors increase while formal station vertical error decreases. (Mapping function errors ~ $1/\sin^3\varepsilon$ so that between 5º and 7º the error decreases by a factor of 0.37.) Looking at the dependence of solution results on the cutoff angle yields information about unmodeled troposphere delay error.

NMF at 5º: wrms $= \sqrt{(1.5\text{ mm})^2 + (0.96\text{ ppb})^2 * L^2}$
NMF at 7º: wrms $= \sqrt{(1.6\text{ mm})^2 + (0.90\text{ ppb})^2 * L^2}$
IMF at 5º: wrms $= \sqrt{(1.5\text{ mm})^2 + (0.91\text{ ppb})^2 * L^2}$
IMF at 7º: wrms $= \sqrt{(1.5\text{ mm})^2 + (0.88\text{ ppb})^2 * L^2}$

=> IMF is better than NMF at 5º and at 7º

IMF and NMF at 7º are both better than at 5º

IMF is marginally better than NMF at 7º